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Feeding Behaviors of Laying Hens With or Without Beak Trimming

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ABSTRACT. *This study quantifies feeding behavior of W−36 White Leghorn laying hens (77 to 80 weeks old) as influenced by the management practice of beak trimming. The feeding behavior was characterized using a newly developed measurement system and computational algorithm. Non−trimmed (NT) and beak−trimmed (BT) hens showed similar daily feed intake and meal size. However, the BT hens tended to spend longer time feeding (3.3 vs. 2.0 h/d, $P < 0.01$), which coincided with their slower ingestion rate of 0.43 g/min−kg$^{0.75}$ vs. 0.79 g/min−kg$^{0.75}$ for the NT counterparts ($P < 0.05$). The BT hens had shorter time intervals between meals (101 s vs. 151 s, $P < 0.01$). Selective feeding, as demonstrated by larger feed particles apparent in the leftover feed, was noted for the BT hens. The leftover feed had a lower crude protein/adjusted crude protein content for the BT birds than that for the NT birds (16.7% vs. 18.7%, $P < 0.05$). In addition, the leftover feed of the BT birds had lower contents in phosphorus, magnesium, potassium, zinc, and manganese ($P < 0.05$), although no significant differences were detected in calcium, sodium, or metabolic energy content. Baseline feeding behavior data of this nature may help quantify and ensure the welfare of animals through exercising proper engineering design and/or management considerations.*

Keywords. *Animal welfare, Ingestion, Poultry.*

The assessment of animal well−being should engage available scientific evidence concerning the feelings of the animals that can be derived from their structure, functions, and behavior (Brambell, 1965). This response assessment criterion includes a scientific evaluation of an animal's sensitivity to all stimuli over different time periods and levels of stimulus (Gates and Xin, 2001). Although many stimuli need to be included to evaluate well−being, it is necessary to analyze the characteristics in individual animal studies to gain a better understanding of the effect that such a stimulus has on the animal. Compilation of the fundamental data can then be applied to management practices to possibly improve the welfare of animals.

The feed trough is a major attraction for laying hens, and the time spent manipulating feed probably reflects the degree of behavioral activation experienced by a hen (Webster and Hurnik, 1991). In the past, video recording and analysis has been used to monitor feeding behavior of laying hens. However, this methodology is time−consuming, costly, tedious, and prone to errors (Gates and Xin, 2001). By using the electronic measurement system and computational algorithm developed by Xin and Ikeguchi (2001), feeding behavior of poultry can be quantified, including the number of meals, meal size, meal duration, ingestion rate, and meal intervals. Collection of such behavioral information represents an attempt toward searching for an objective, quantitative, and non−invasive means to measure animal welfare, which continues to challenge the academic community and the animal industry alike. The objective of this study was to comparatively quantify feeding behavior of laying hens with or without beak trimming, which could reveal information about management or design decisions that would lead to enhanced animal welfare.

LITERATURE REVIEW

An intensive poultry production system often criticized in the U.S. is caged laying hens (Becker, 1992). Beak trimming is considered a necessary management practice in the poultry industry to prevent cannibalism and reduce social stress among birds (Lee and Craig, 1991; Duncan, 1992; Swanson, 1995). The physical damage that untrimmed birds can inflict on one another has serious effects for the birds (Struwe et al., 1992; Dutch Society for the Protection of Animals, 1996). Noble and Nestor (1997) reported that large−bodied turkeys have been selected for maximum performance with trimmed beaks. However, improper beak trimming procedures can result in permanent damage to overall performance of hens (Christensen, 1984). Chronic pain may be associated with feeding following beak trimming (Gentle et al., 1990; Cunningham, 1992; Duncan, 1992; Clough and Kew, 1993; Lunam et al., 1996; Dunayer, 2001).

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According to the Variety W-36 Commercial Management Guide (Hy-Line, 2002), W-36 pullets are generally trimmed between 7 and 10 days of age, 2 mm from the nostrils. Glatz (2000) suggested that high-quality beak trimming at this age has very little effect on weight gain compared to beak trimming at 10 to 12 weeks of age. It is recommended that immediately after trimming, the depth of the feed should be increased in the pans or troughs to encourage birds to eat and to prevent additional stress caused by beak tenderness (Christensen, 1984). Deaton et al. (1988) reported that beak trimming of roaster broilers at 56 to 70 days of age did not significantly affect weight gain or feed consumption. The argument can be made that although animals are feeling “something” this does not translate into an experience that may be similar to a human with feelings of fright, frustration, or pain (Dunayer, 2001).

Behavior is a useful indicator of animal well-being. A composite average feed ingestion behavior of birds in a treatment may mask useful, dynamic information (Puma et al., 2001). Behavior of individual birds at the feeder, if quantified, could form a comparative basis for assessing alternative management and housing strategies. Gates and Xin (2001) compared two algorithms that utilize time-series recordings of feeder weights as the bases for assessing individual bird feeding characteristics.

Animal agriculture is increasingly dealing with outcries regarding animal welfare issues. At the federal level, only limited legislation exists related to humane animal treatment, and there is none related to animals residing on-farm (CAST, 1997). However, most farmers recognize that deterioration in the welfare of their animals will result in reduced productivity and health of the animals, and thus a potential loss of profitability (Hemsworth and Coleman, 1998).

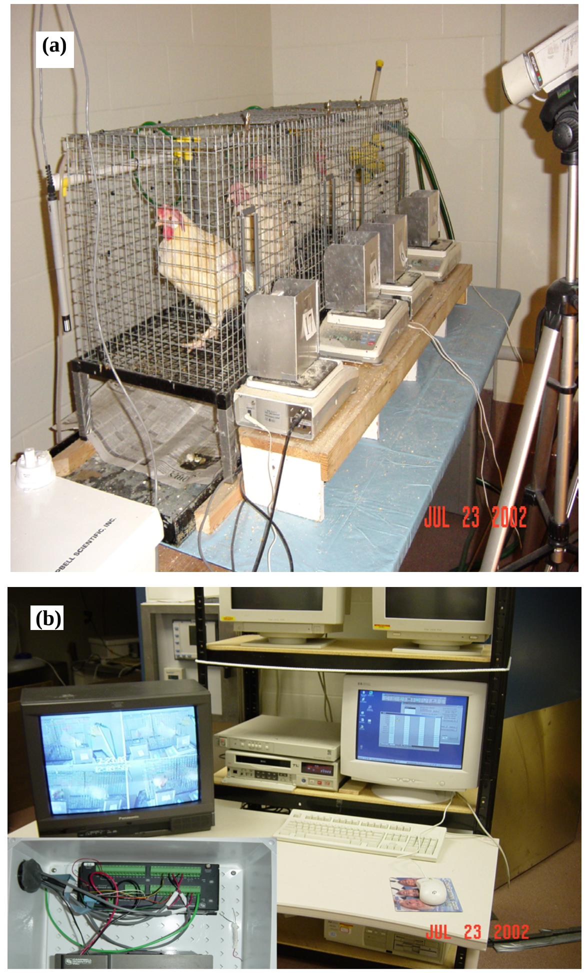

Figure 1. Photographic views of (a) testing room showing four individual feeding stations and monitoring video cameras, and (b) image and data acquisition system.

Materials and Methods

System Setup

The testing and holding rooms (4.6 L × 2.7 W × 2.6 H m) used for this study were environmentally controlled. Thermal conditions were monitored and recorded every 5 min with portable data loggers (HOBO H8 Pro Series RH/Temp. Onset Computer Corp., Pocasset, Mass.) placed in both rooms and a temperature/RH probe (model HMP35C, Campbell Scientific Inc., Logan, Utah) located in the testing room. A thermoneutral air temperature of 21°C (±1°C) and RH of 55% to 65% were maintained in the rooms. About 10 lux of illumination throughout the holding and testing rooms was provided for a 16 h light period (5:00 a.m. to 9:00 p.m.). The illumination at bird level was periodically checked with a digital light meter (model DLM2, Cole Parmer Instrument Co., Vernon Hills, Ill.).

The experimental birds in the holding room were housed individually in wire-mesh cages with a floor space of about 1200 cm^2. Each cage was equipped with a nipple drinker and a plastic feeder (13 L × 13 W × 15 H cm) placed outside the cage. The testing room held four birds in individual stations with a floor space of 1750 cm^2 (fig. 1a). Aluminum feeders (13 L × 15 W × 11 H cm) with a U-shaped access opening were attached to electronic balances (2200 ±0.1 g, model GX 2000, A&D Company Ltd., Tokyo, Japan) with Velcro strips (fig. 1a).

The balances each had a linear analog output of 0 to 2.2 VDC corresponding to the weighing range of 0 to 2200 g, and the output was connected to the electronic data logger (model CR10X, CSI, Logan, Utah). The balances had an automatic response adjustment that adapts to potential vibration or drafts in the environment. The balances were set to continuous comparison mode, which included near-zero readings. Balance sample readings were recorded at 1 s intervals. The data were then automatically retrieved to a PC every 2 h using the PC208W program (CSI, Logan, Utah), and the resultant files were saved and backed up once every 24 h.

Four video cameras (Panasonic model WV-CP410) were used to continuously monitor and record the birds’ duration and frequency at the feeders in the testing room. Two of the cameras were focused on two individual birds (cages 1 and 4), while the other cameras shared a full picture of neighboring birds (cages 1 and 2, and cages 3 and 4). Images from the four cameras were displayed on a color video monitor via a Quad System (Panasonic model WJ-420) and were recorded on a time-lapse VCR (Panasonic model AG-6730, recording speed of 72 h/tape) (fig. 1b). Because viewing these video recordings is time-consuming and tedious, the recordings were selectively used for algorithm validation purposes only, or as backup in case of uncertainty with the recorded feeder weight data.

Experimental Birds

Hy-Line W-36 White Leghorn laying hens at an initial age of 77 weeks were procured from a cooperating company in

Iowa. There were a total of 27 hens, of which 13 were non−trimmed (NT), designated as the control group, and the other 14 hens were beak trimmed (BT). The BT birds had previously been trimmed 2 mm from the nostrils at between 7 and 10 days of age, as recommended by Hy−Line (2002). The hens were placed and acclimated in individual cages upon arrival at the Livestock Environment and Animal Physiology (LEAP) Lab II at Iowa State University. During the first day in the holding room, body mass was recorded, and each hens was labeled with an identification number taped around the leg. Feed use was monitored daily in the holding room, and the individual feeders were refilled between 10:00 and 10:50 a.m. Daily egg production was also recorded in both the testing and holding rooms. A commercial diet was used, containing 2895 Cal/kg ME, 15.8% crude protein, 0.82% lysine, 0.33% methionine, 4.18% calcium, 0.315% phosphorus−AV, and 0.176% sodium.

Because only four measurement stations were available in the testing room, 20 experimental hens were divided into five replicate sub−groups, two birds of each beak type per sub−group. The seven remaining hens served as backups in case of mortality. Each hen within a sub−group was randomly assigned to the testing cage (1 to 4). Before the hens were placed in the testing room, body mass was recorded. Following a 3−day acclimation, feeding behavior was monitored for the next 48 h and used in the subsequent analysis. The hens needed time to acclimate to their new surroundings, including the cage, neighboring hens, and cameras. It was found that after three days in the testing room, the daily feed consumption of the hens was at least 95% that of the average feed daily intake, measured for a particular hen in the holding room.

Feed was replenished on the first, third, and fifth days of the trials. Each sub−group was used for one trial. Upon completion of each trial, body mass was recorded again before returning the hens to the holding room.

Analysis of Feeding Characteristics

Ingestion characteristics of the laying hens and the effects of beak trimming were evaluated using the analysis protocol developed by Xin and Ikeguchi (2001). Meal size (MS, g/meal−kg$^{0.75}$), meal duration (MD, s/meal), ingestion rate (IR, g/min−kg$^{0.75}$), and meal interval (MI, s) were characterized for the feeding events. In order to obtain these measurements, it was necessary to determine the beginning and ending time of each meal as well as the weight of the feed on the scale before and after each meal. A threshold of 0.2 g in feeder weight change was used for determination of a true feeding event. A time span of at least 15 s during which the recorded feed weight remained stable was used to define the break between two adjacent feeding/meal events. Daily feed use values, as determined from the algorithm and the manual weighing of the feeders at the beginning and end of the day, were within 5%. Samples of feeding event signals are shown in figure 2. The feeder weight data recorded during the dark hours of 9:00 p.m. to 5:00 a.m. were excluded from the analysis due to no feeding activity of the birds.

Distributions of MS, MD, IR, and MI were heavily skewed to the right for each bird. Thus, statistical analysis of the ingestion characteristic data was conducted on the natural logarithm scale to dampen the effect of rare but large outlying observations. Bird means were computed for the logarithm of the MS, MD, IR, and MI variables. Body mass (kg), metabolic mass unit (kg$^{0.75}$), daily feed intake (g), number of meals per

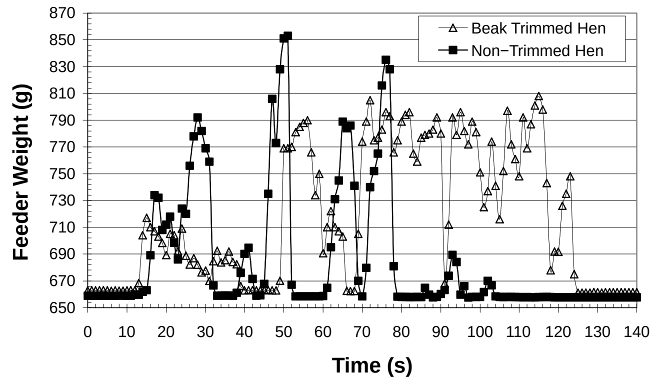

Figure 2. Sample raw data of feeder weight associated with feeding events of the hens.

day, and total hours spent on feeding per day were also determined for each bird. A linear model analysis using the GLM procedure of SAS version 8.2 (SAS, 1999) was used to test for the effect that beak trimming had on each of these hens and their feeding characteristics. Terms for cage, sub−group assignment, and beak type were included in the model to assess the effects of beak trimming while controlling for the potentially important effects of cage and sub−group assignment. One bird from each beak type was excluded from statistical evaluation due to inadequate data, leaving the total number of birds analyzed at nine birds per beak type. In addition to the feeding characteristics, six samples of remaining feed from six different birds of each beak type were collected at the end of the trials. Nutritional composition of the leftover feed samples, along with a composite sample of the original feed, was analyzed by a certified commercial feed analysis laboratory (Forage Testing Laboratory Dairy One, Inc., Ithaca, N.Y.).

Results and Discussion

The hen and hen feeding characteristics are summarized for each beak type in tables 1 and 2. The frequency distributions of each feeding characteristic are presented in figure 3 (MS), figure 4 (MD), figure 5 (IR), and figure 6 (MI), respectively. Figures 3 to 6 cumulatively reflect at least 95% of the data points. The most extreme points have been excluded from the graphs to maintain resolution in the lower data range, where the bulk of the data fall. The use of metabolic mass unit (MMU, kg$^{0.75}$), where appropriate, was to minimize the effect of different body size.

As shown in table 1, no significant difference between beak types was detected for body mass, metabolic mass unit, daily feed intake, and number of meals per day. Table 1 also indicates that the BT hens spent significantly more time feeding than the NT hens, averaging 3.3 vs. 2.0 h per day to consume a similar average number of meals per day, 107 for the NT hens and 99 for the BT hens. Table 2 indicates that the BT birds exhibited a significant increase in meal duration and a significant decrease in ingestion rate and interval between meals. In particular, the duration of meals for the BT hens was 2.06 times as large as the duration of meals for the NT hens. A 95% confidence interval for the multiplicative effect is 1.14 times to 3.73 times. The p−value when testing for a difference in means on the log scale was 0.023. Results for the other variables in table 2 can be interpreted similarly. Note that

Table 1. Mean and standard error (SE) of body and feeding characteristics for the non−trimmed (NT, *n* = 9) and beak−trimmed (BT, *n* = 9) hens.

Body Mass and Feeding Characteristics	NT		BT		p Value[a]
	Mean	SE	Mean	SE	
Body mass (kg)	1.446	0.032	1.493	0.031	NS
Metabolic mass unit ($kg^{0.75}$)	1.319	0.022	1.351	0.021	NS
Daily feed use (g/hen)	82.3	5.5	87.4	6.3	NS
Number of meals/day	107	12	99	10	NS
Total time spent on feeding (h/day)	2.0	0.2	3.3	0.4	0.007

[a] NS = means not significantly different.

Table 2. Average body mass, daily feed use, number of meals per day, and total hours spent on feeding per day for the non−trimmed (NT) and beak−trimmed (BT) hens.

Feeding Characteristics	Back Transformed Mean		Multi−plicative Effect	95% C.I. of Multiplicative Effect		p Value[a]
	NT	BT		Lower	Upper	
Meal size (g/meal−$kg^{0.75}$)	0.52	0.58	1.12	0.91	1.38	NS
Duration (s/meal)	39	81	2.06	1.14	3.73	0.023
Ingestion rate (g/min−$kg^{0.75}$)	0.79	0.43	0.54	0.34	0.88	0.019
Interval (s)	151	101	0.66	0.53	0.83	0.002

[a] NS = means not significantly different.

the meal size effect was not statistically significant at the 0.05 level because the 95% confidence interval for the multiplicative effect (0.91 to 1.38 times) did not rule out a multiplicative effect of 1.0 (i.e., no effect). The similar MS but longer MD for the BT hens led to a slower IR for BT (0.43 g/min−$kg^{0.75}$) as compared to the NT hens (0.79 g/min−$kg^{0.75}$) (P = 0.019). The seemingly long time taken to ingest 1 g of feed for both beak types might be attributed to "non−essential" feeding activities, such as playing with or searching in the feed (Hughes and Duncan, 1988; Picard et al., 1997; Yo et al., 1997).

During the study it was observed that larger particles of feed remained in the feeders of the BT hens at the end of each trial period, as shown in figure 7. Work by Portella et al. (1988) suggests that feed particle size influences disappearance rate of feed among non−trimmed laying hens, with large particles being preferred and consumed before smaller particles. As a result, feed intake can be restricted or stimulated by adjusting particle size, if the nutrient composition of the diet remains the same (Portella et al., 1988). Deaton et al. (1987) reported that pullets that were beak trimmed 2 mm from the nostril had significantly higher weight loss when given a pellet diet compared to pullets fed mashed diet. Results of the current study shed further light into the proper form of feed that should be provided to BT birds. Although not quantitative, it can be seen from figure 2 that hens of different beak types tended to feed quite differently. The NT hen tended to have more discrete picks, whereas the BT hen seemed to remain in contact with the feed more during feeding. A question may be asked: Does the NT hen take in feed mostly by pecking, while the BT hen does so mostly by scooping? A quantification of the vertical vs. horizontal forces of feeding for the two beak types may help further elucidate this behavior.

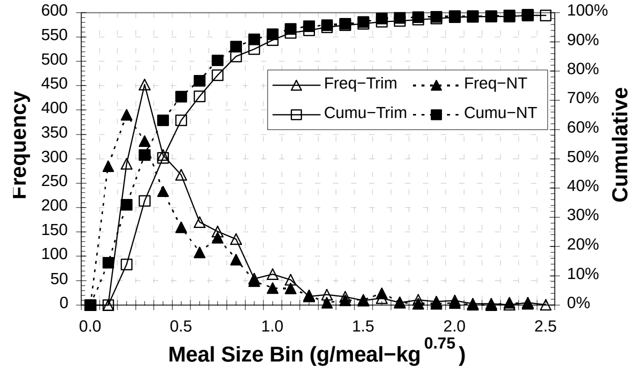

Figure 3. Frequency distribution of meal size for laying hens with trimmed (Trim) or non−trimmed (NT) beak, based on 2 day feeding data of 9 hens per beak type.

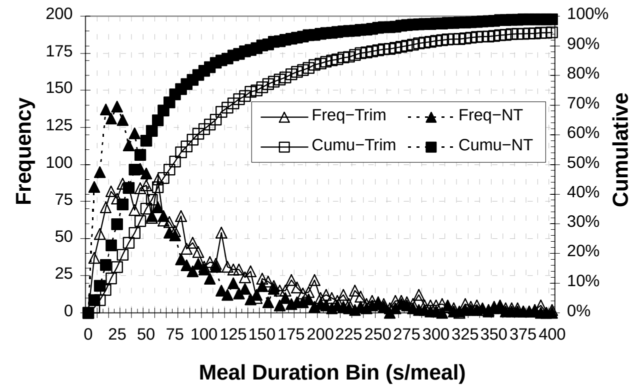

Figure 4. Frequency distribution of meal duration for laying hens with trimmed (Trim) or non−trimmed (NT) beak, based on 2−day feeding data of 9 hens per beak type.

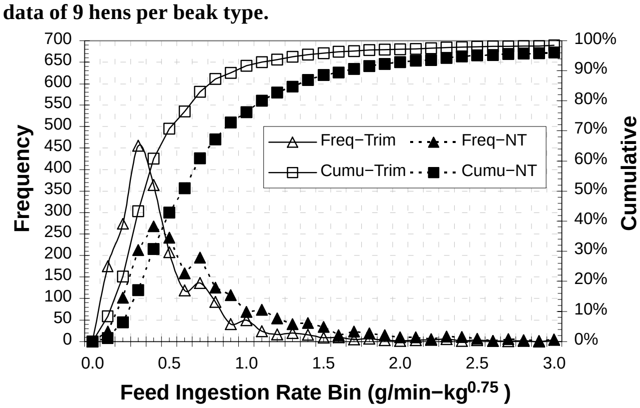

Figure 5. Frequency distribution of ingestion rate for laying hens with trimmed (Trim) or non−trimmed (NT) beak, based on 2−day feeding data of 9 hens per beak type.

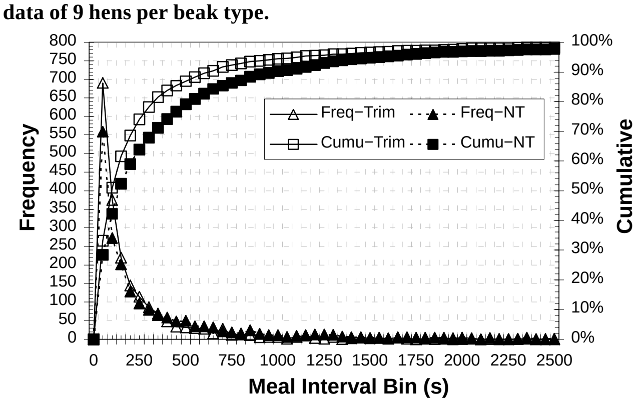

Figure 6. Frequency distribution of meal interval for laying hens with trimmed (Trim) or non−trimmed (NT) beak, based on 2−day feeding data of 9 hens per beak type.

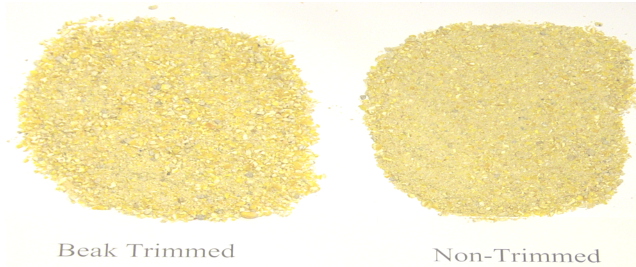

Figure 7. Samples of feed particles remaining in feed trough from one non−trimmed bird and one beak−trimmed bird after the trial was completed.

As shown by the data in table 3, a lower percentage of crude protein (CP) or adjusted CP (16.7%) remained in the leftover feed of the BT hens as compared to that (18.7%) for the NT birds. The lower CP content was presumably attributed to the larger corn particles, which have lower protein content than soy−meal of smaller particles. The speculated pecking (NT hens) vs. scooping (BT hens) ingestion behavior might have contributed to this outcome. Other elements of lower contents found in the leftover feed of the BT included phosphorus, magnesium, potassium, zinc, and manganese. Calcium, sodium, and metabolic energy values were similar for both beak types.

Conclusions

The following conclusions were drawn from the current study concerning feeding characteristics of 18 laying hens either with beak trimming (BT) or non−trimming (NT):

- Both NT and BT hens showed similar daily feed use and meal size. However, the NT and BT hens also displayed some subtle differences in their feeding dynamics. Specifically, the BT hens spent longer time at the feeder (3.3 h/d vs. 2.0 h/d), coinciding with a slower ingestion rate of 0.43 g/min−kg$^{0.75}$ vs. 0.79 g/min−kg$^{0.75}$ for the NT hens and shorter time intervals between meals (101 s vs. 151 s).
- Beak trimming seems to have an impact on the way the hen takes in feed, as evidenced by the feed pecking patterns and the particle distribution in the leftover feed (larger particles for the BT birds). Leftover feed for the BT hens tended to have a lower content in crude protein, phosphorus, magnesium, and potassium, but similar values in calcium, sodium, and metabolic energy content.
- The results demonstrate the adaptability of the hen to beak trimming in terms of achieving its daily feed/energy intake by varying its ingestion dynamics or pattern.
- More data of this nature are needed to better understand and quantify the potential impacts of management practices on hens and ultimately ensure their welfare.

Table 3. Nutrient profiles of original and leftover feed for the non−trimmed (NT) and beak−trimmed (BT) hens (*n* = 6).

Feed Ingredient Parameter	Original Feed Value	NT Mean	NT SE	BT Mean	BT SE	p Value[a]
Moisture content (%)	10.1	8.9	0.1	9.1	0.4	NS
Dry matter (%)	89.9	91.1	0.1	91.0	0.3	NS
Crude protein (%)	16.5	18.7	1.1	16.7	1.7	0.040
Adj. crude protein (%)	16.5	18.7	1.1	16.7	1.7	0.040
ADF (%)	2.6	2.2	0.3	2.1	0.4	NS
NDF (%)	8.0	7.1	0.4	7.0	0.1	NS
Calcium (%)	5.5	6.7	0.6	7.3	1.1	NS
Phosphorus (%)	0.35	0.45	0.01	0.38	0.05	0.004
Magnesium (%)	0.17	0.20	0.01	0.17	0.01	0.001
Potassium (%)	0.81	0.91	0.01	0.78	0.10	0.020
Sodium (%)	0.19	0.23	0.02	0.21	0.03	NS
Iron (PPM)	272	406	109	357	60	NS
Zinc (PPM)	92	106	8	85	9.6	0.002
Copper (PPM)	21	28	3	26	4.8	NS
Manganese (PPM)	95	115	7	93	12	0.002
Molybdenum (PPM)	2.3	0.9	0.7	1.2	0.7	NS
ME as−is (Kcal/kg)	3137	3184	11	3190	17	NS
ME DM (Kcal/kg)	3490	3496	9	3506	12	NS

[a] NS = means not significantly different.

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